

ABANDONED MINE SITE RESTORTION ON PINE CREEK, COEUR D=ALENE BASIN, NORTHENR IDAHO

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ABSTRACT

Following severe flooding in northern Idaho in 1996, the Bureau of Land Management (BLM) and partners began implementing a systematic restoration of the Pine Creek watershed to reduce the impacts of past mining and milling. This work is continuing to progress as part of the Idaho's Abandoned Mine Lands (AML) program and the Coeur d=Alene Basin cleanup activities with the Environmental Protection Agency and the State of Idaho. This ongoing, multi-year effort includes a variety of sites in a mountainous 79 square-mile watershed. Actions to date include streamside tailings removals, mill site cleanups, stabilization of waste rock dumps, and stream restoration. This paper will focus on the mine waste removals and waste rock dump stabilization aspects of the restoration effort.

Contaminants of concern are primarily lead, zinc, cadmium and arsenic. Site characterization methods included: site surveys, historic information reviews, field sampling with a portable X-Ray Fluorescence (XRF) unit, transect sampling of soils with XRF and laboratory analysis and periodic water quality monitoring. Limitations and benefits of various characterization and sampling methods are briefly discussed and compared.

Interpretation of sampling data, specific-site characteristics, and cost/benefit limitations, were all considered in design of projects. Project design plans, contract administration, on-the-ground implementation, and preliminary results are also presented as examples of factors involved in conducting AML projects.

BACKGROUND

Pine Creek is located just south of Pinehurst in Northern Idaho's historic Silver Valley. Most of the sites are located along the East Fork of Pine Creek within the Pine Creek watershed. This watershed encompasses an area of approximately 79 square miles and includes the area commonly referred to as the Pine Creek Mining District, a subdivision of the larger Coeur d'Alene Mining District known as the "Silver Valley". The Coeur d'Alene Mining District has been one of the largest metal producing areas of the United States and the largest silver-producing district in the world. The Pine Creek District covers a lead-zinc area which from the early 1900s to the late 1970s, ore was processed at nine flotation mill sites. Seven abandoned or inactive mill sites are located either partially or entirely on BLM administered lands (public lands) within the Pine Creek watershed.

During the winter of 1995-96, several old mine and mill sites and stream segments in the Pine Creek drainage were severely damaged by flooding. BLM received flood repair and protection funding to remove tailings that were in imminent danger of flood erosion and to rehabilitate stream channels. The flood and other cleanup funding provided the opportunity to further investigate and

begin cleanup actions at many sites within the basin. Preliminary investigations had indicated that areas in and adjacent to the mill and mine sites were contaminated with heavy metals. Lead, zinc, cadmium, and arsenic are the contaminants of concern in Pine Creek. The widespread distribution and toxic properties of these metals has the potential of adverse effects to fish, wildlife, and humans.

This paper will focus on the Pine Creek mine waste removals and waste rock dump stabilization aspects of the watershed restoration effort. A general synopsis of issues and methods used in the process of AML site characterization and cleanup, and lessons learned are presented here.

In the conference presentation, more detail on specific AML sites will be provided as illustrations of the effort. An accompanying paper (Stevenson and others, 2002, in this volume) covers stream-restoration aspects of the Pine Creek projects.

SITE CHARACTERIZATION

Site characterization for BLM's AML and Hazardous Materials efforts are done using the process of the National Contingency Plan (NCP) (NCP, 40 CFR, Part 300). Site characterization is an iterative process in assessing problems at the site, and determining if, and how to best cleanup the site. The general NCP process is as follows:

1. site identification;
2. preliminary assessment (PA);
3. site investigation (SI);
4. removal site evaluations (Engineering Evaluation/Cost Analysis - EECA) or remedial investigations/feasibility study (RI/FS);
5. removal cleanup decision or remedial Record of Decision (ROD);
6. project design; and
7. project implementation.

After a site has been identified as having potential problems, the preliminary assessment and site investigation collect the information to determine if a release has occurred and whether a cleanup action is warranted. If a cleanup action is needed, the next stage of characterization is to collect the information to determine how to best cleanup the site. The extent of investigation is determined by the project funding source and the documentation required to implement the project. The removal process under the authority of a lead agency can be every effective with AML sites with normal problems and needed actions. The remedial process, usually done by the Environmental Protection Agency, is for more complex or controversial sites. The remedial investigations and process can easily cost 10 times the cost of a removal investigations and process for the same site.

Initial field investigations are to inventory the basic features at a site and for the preliminary assessment. The potential pathways are examined and initial sampling is done to confirm if releases and problems are actually located at the site. From the preliminary site assessments, the site investigation needs for further site information are identified to determine whether a cleanup action is warranted. The site investigation normally includes checking surface and ground water quality and collecting soil samples to determine the relative magnitude and the aerial extent of the soil contamination. More detailed AML removal site assessments factors are discussed in the following sections based on our Pine Creek and Coeur d'Alene basin removals and investigations. The basic plan for many of our removal sites and their characterization can be found in our EECA for Pine

Creek Millsites (CCJM, 1998).

Once an AML site is targeted for investigation, a literature search is useful in determining the type of mining and milling processes, extent of the mining and ore production, and types of contaminants and physical hazards that are likely to be found. US Geological Survey (USGS) reports, Bureau of Mines reports and State mining bureau reports, which cover the local area, are usually good starting points. Other places to collect historic site information include mining databases, mineral claim and patent survey documents, courthouse records, Sanborn fire insurance maps and checking local historic maps, books, papers and museums.

The initial site surveys have been field visits to map out site features to develop initial site sketches from field observations. The field information can be added to geographic information systems (GIS) with USGS topographic maps and orthophotos to develop initial site maps. Now global position system (GPS) units are also being used to locate and map site points and features which then can be added into GIS maps. For the site investigations and project designs site base maps are expanded with site topographic surveys and low-level aerial photography.

Soil sampling of the waste materials can be a major task with the variety of materials and concentrations that can be found at mines and mill sites. The use of a field portable X-Ray Fluorescence (XRF) unit is a particularly helpful tool in identifying heavy metal contamination in mining related site investigations. The XRF is also excellent at doing transects and checking test borings/pits to quickly determine the extent and magnitude of the contamination. During and after the removals, the XRF can check, confirm and monitor the cleanup levels. The XRF unit is quite cost effective to screen and select which confirmation samples should be sent to the laboratory for analysis.

Water quality sampling is a part of AML investigations from beginning to the end of the project and beyond. Initial investigations collect basic water quality for contaminants or indicator parameters from the surface water streams above and below the sites, any mine drainage and local seeps that might indicate ground water characteristics. If there is significant ground water contamination, monitoring wells are added and included in the site investigations and monitoring. Periodic water sampling of points within the Pine Creek watershed is being done to determine seasonal variations and to identify priority action needs. Periodic water quality monitoring of points within a watershed and at specific sites is necessary to assess the success of clean up efforts and to monitor the long-term water quality.

TAILINGS REMOVALS

The Pine Creek tailings removals have consisted of two types: (1) mill site tailings piles; and (2) deposited floodplain tailings. The removal of the floodplain mill site tailings piles that were being eroded by the streams, was the first priority to be removed. The mill site tailings usually have tailings dams or dikes around and below the tailings that define the boundaries and control the height of the tailings. At several of the sites the streams had eroded away the dikes or flowed over the impoundments, eroding the tailings into the streams.

The characteristics of mill tailings vary with how the site was operated. At many of the older mill sites, the tailings were dumped on the original floodplain to flow to and be carried off by the stream. When the stream did not have the capacity to transport them away, impoundments would be formed with dikes. During the removals we often were working around or removing old tree stumps

and floodplain debris while removing the tailings. The tailings impoundments are generally layered, reflecting a progression in milling practices, or a variation in ore mineralogy. The deeper layers usually contain higher concentrations of metals, since older milling practices were not as effective in beneficiating the metals. Also the upper layers are usually leached and oxidized. The digging of test pits and XRF analyses were usually used to confirm the extent of the tailings.

While the tailings in the impoundments were easy to locate and characterize, the floodplain tailings were widely distributed and presented significant challenges. The major deposits of floodplain tailings are located at variable distances below the mill sites and occur where floodplain widening and stream-gradient reductions cause the bedload to readily drop out of suspension and become deposited. The past dumping of tailings during low flows increased bedload filling in the stream channels and greatly contributed to destabilizing the streams (Kondolf and Matthews, 1996). High flows and over bank flows carry the tails further through the system and deposit them on the upper banks of the floodplains. These higher flows scour the channels and rework floodplain deposits, mixing the tails with the other sediments carried and eroded by the streams. With a destabilized stream, large flood events enable further mixing of tailings and sediments as the channels shift and erode the upper bank areas and redistribute the deposits.

To locate stream deposited tailings, it is very important to understand the stream dynamics and geomorphology of the stream. Local visual indicators, such as silt- and clay-sized material, lack of vegetation, and rusty oxide colors, are useful in identifying tailings. Old tree stumps, debris, and original organic soil layers are useful for determining depth. In areas particularly of old milling operations or reaches with extensive flood activity, the tailings can be concealed beneath clean sediments that support generous vegetation. The revegetation makes these areas hard to recognize and characterize. Estimating volumes for removals are extremely difficult due to the reworking of the deposits by the stream. During the excavation of the deposits, additional volumes of tailings are often discovered that have been obscured by newer stream deposits.

Decisions for removals of streamside tailings can be complicated by the complexity of the deposits. Priorities used for the removal areas were: (a) highest concentrated deposits; (b) areas nearest the stream or in old floodways that are susceptible to erosion; (c) leachable deposits in the zone between high and low ground water levels; and (d) areas that are used by recreational users (for protection of human health). During the removal work, keep focused on the priority removal areas and track the progress versus the budget available. Since the volume of the removal is directly proportional to costs, careful monitoring of the excavation (e.g., with an XRF unit) is necessary to conserve costs.

Often a difficult decision is whether tailings buried by newer sediments with established vegetative cover are to be removed. The decision can be made by weighing the thickness and hazard level of the tailings level versus the amount of overburden and vegetation. The onsite XRF analysis of the layers and sediments during the removals have been key to many of the field decisions. Often visual indicators cannot alone distinguish clean soil from tailings, especially when they are buried below the water table and the tails have not been oxidized. In some areas with tailings beneath clean sediments and established vegetation, it may be more prudent to leave undisturbed.

MILLSITE REMOVALS

Removals were undertaken at the mill sites on public lands by cleaning and removing wastes materials

from and around the mill building locations. Mill sites can have widely varying conditions depending on the type of processing that was done at the site; the location from the mine and how ore was brought to the mill; the means of mine and mill waste disposal; and if the mill has been demolished and/or burned. At some of the sites, found were past generations of mills below or beside the current mill features. The older mills used stamp mills and jigs that depended upon gravity separation, thus not as efficient as newer flotation mills. The tailings from these mills contain relatively high concentrations of remnant metals and the flattened particles can be more readily leachable than other tailings. The improved grinding methods associated with the newer flotation mills resulted in very fine particles that are easily transported by wind and water. Process chemicals used in the flotation mills may also add another component of the contamination problems.

The location of the mill in relation to the mine makes the transport route of the ore important to identify, since increased levels of contamination may exist along that route. Sites examined have had varied ore transport systems ranging from the mine cars on rails to aerial bucket trams to large railroad and truck transports.

The mine and mill waste handling at the mill site are usually important to identify, since these waste piles are usually the most pressing cleanup needs. The tailings piles were discussed above and the mine rock dumps will follow. We have found extensive wastes around, in and below the mill buildings. The highest metal concentrations found were associated with spilled concentrates in loading and storage areas. Other high level contamination exists in chemical storage areas and around and below the flotation units and the ball mills. Milling dust and the waste tailings are extensively found all around mill sites. The waste disposal pathways are important to track, since contamination is usually elevated there.

In the case of mills that have been demolished or burned, concentrated metal wastes are mixed with, and/or concealed by the debris and ash. Usually the old concrete foundations for the large milling and floatation machinery can be found and the knowledge of the basic processing flow can give one a general layout of areas needing to be cleaned up. Old fire insurance maps can be a very helpful source of the layout of buildings at a site and may also give one a time history of the facilities. Cleaning up demolished and burned sites are also made more difficult due to the physical hazards that need to be worked around in the characterization efforts and during the actual cleanup work.

Before the cleanups were started, the mill sites were documented and recorded by cultural specialists. Part of the cleanup plans was to leave the large concrete foundations or other historic features, where possible, to leave part of the history of the local area. During the mill cleanups we found that much of the work in the building areas and around the old foundations needed to be done by hand or with bobcats or mini-hoes. Also with the hand labor, small crews worked better because they worked together better and the larger crews seemed always to have some workers waiting for directions. After the concrete foundations and slabs had the materials removed from them, the areas were flushed using hoses from water trucks.

WASTE ROCK DUMPS

While removals of heavy metal contaminated tailings decreases potential for water quality problems, waste dump stabilization has been done primarily for reduction of sediment input into the watershed. Waste dumps in direct contact with streams have caused increased bedload, which has been hypothesized (Kondolf and Matthews, 1996) to be a major cause to the channel instability in the Pine

Creek reaches. At most all of the major producing mines, the extensive amounts of waste rock generated has created dumps that either completely fill over the steep walled canyon draws or severely encroach on the streams floodplains. Since most of the streamside dumps are at least at the angle of repose, the dump is significant long-term sediment source. With the large volumes of waste rock, an excavated removal is usually not practical or economical, so stabilization consisting of pulling back from and armoring the stream, reduction of slope, terracing, and revegetation has been pursued.

A good topographical survey using a total station survey unit which imports data into a computer aided drafting (CAD) system expedites designing regrading options and volume estimates. The topographic survey should include all of the mine related features and the areas where the materials might be moved to. Stream features and dump erosion areas need to be well identified since they are the key removal action areas.

The rock dump projects have been onsite regrading, but in the case of highly contaminated waste rock, moving to another site may be needed. The rock dumps are usually a mixture of rock, ranging from clean parent rock to low-grade ore rock. The sites have been in steep draws, which cannot be regraded to where the stream originally flowed. During spring runoff periods, subsurface flow through the pile in the original stream areas are often seen. These flows are not a concern if they do not create significant erosion or water quality issues, or dewater a fishery stream segment.

STREAM STABILIZATION

As part of the mine related removal work, the sites are being revegetated and the stream channels stabilized. The tailings impoundment removals in the floodplains generally require subsequent restoration of the stream and the floodplain. The floodplain tailings removals usually resulted in the need to backfill areas next to the streams or the reconstruction of the stream zone and floodplain. More details on the issues dealing with stream restoration in Pine Creek are presented in a companion paper in this volume (Stevenson and others, 2002).

MINE WATER TREATMENT

Seeps and mine adit discharges are often a major source of water quality degradation. Treatment of these sources often is the only reasonable option to address these sources. Mine water characteristics and potential treatment options vary considerably with mine characteristics, climatic factors, and geochemistry. In other words, what works in one area may not work in another. Design procedures are not well established to design mine water treatment systems because systematic research of the systems has been very limited.

Due to the regional mine site variations, pilot systems usually are needed to evaluate system effectiveness and gather the additional characterization information. Mine discharge rate and seasonal water quality variations need to be considered in system design. Abandoned mine site systems in our mountainous region require very limited operation and maintenance needs because the sites are remote, without power and inaccessible for most of the winter and spring. In the Coeur d'Alene basin, we have started experimenting with several pilot treatment systems trying small tank units with bioreactors and zeolites. We are installing further pilot bioreactor cells (subsurface flow wetland concepts) and a tank system using biochelators. These pilot systems are being tried to investigate

what may work with our regional mine characteristics and weather conditions. From the first winter of operation, we found that our units that are buried flush with the ground did not appear to have any freezing problems during the winter with a good snow cover. There appears to be no easy answers. This is a significant area of experimentation and a future area of applied research.

SOME OTHER LESSONS LEARNED

Time and materials (T&M) contracts with capped limits have provided flexibility in AML cleanup work. With T&M contracts, one needs to keep focus on the removal priority needs. On-site oversight of the contractors is essential to: keep priority work on track; track overall progress and expenditures; and to assure work is done properly. If possible do not work during extended adverse weather conditions, which make efficiently decline or threaten to compromise the environmental protection controls. T&M contracts shift the risk of work not working correctly or taking much longer than planned from the contractor to the one paying for the contract. The contractors will get paid for the work they are directed to do, and the contractors know that well, so under a T&M contract one needs to know what they are doing.

Abandoned mines and mill sites can be very expensive to extensively characterize and can cost more than the cleanup needs in the end. If contracting the characterizations, carefully define what is to be investigated and what data needs to be collected. A contractor can always find more questions that they would like you to pay to answer. With flexible cleanup contracts, a good contractor, past experience at similar sites, and tools like the XRF, cleanups can be done very cost effectively with limited general characterization. A portable XRF unit can pay for itself during a large removal in the savings gained during the site characterization and by determining what needs, and does not need, to be removed.

A good topographic site survey with a total station is needed for a mill site cleanup or rock dump regarding project base maps. For streamside tailings and stream stabilization efforts, low-level aerial photos enlarged to a scale of 1 inch = 100 feet have been very effective as project base maps. Project base maps are important to be able to estimate the removal volumes, to map the planned removal areas and to locate the stream stabilization needs for the project planning, contract documents and project documentation.

Working with AML sites is challenging because of the widely varying conditions encountered at the sites. We need to share our findings - what works, and what doesn't - so we can improve solutions of water quality and safety on our public lands. From BLM's Characterization of Abandoned Mine Lands course, Mike Browne's ending slide in the approach session struck a true note: **"Good judgment comes from experience, and a lot of that comes from bad judgment."** (BLM, 2002). We often learn more from our mistakes than our successes, so one should not be afraid to try to do what one believes is reasonable to do.

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